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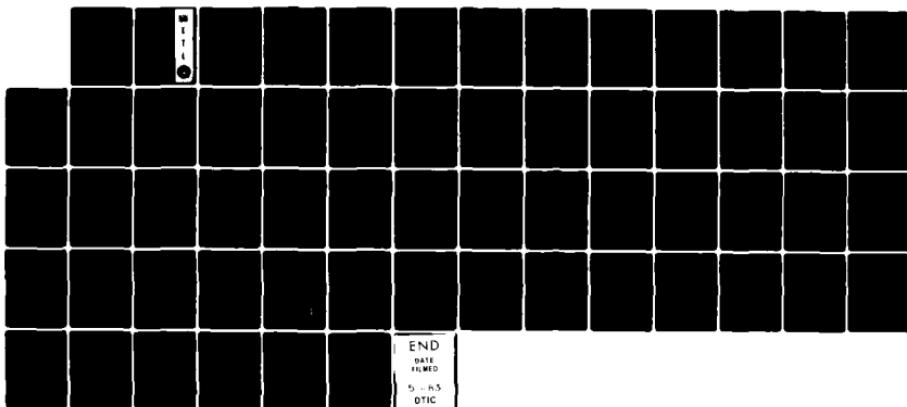
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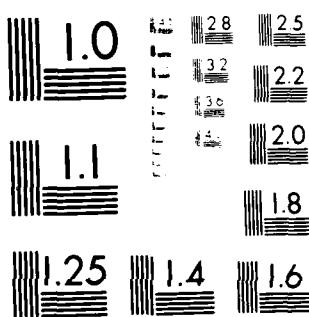
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ETL-0312

Interactive image analysis  
system design

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DECEMBER 1982

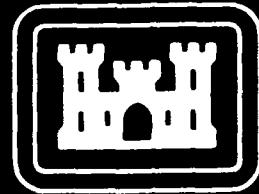
Prepared For

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)  This report presents requirements analysis and a system design for an interactive image analysis system capable of performing the Terrain Data Extraction process, which is described in detail in report ETL 0241 and others. The system is based on a VAX 11/750 minicomputer with a DeAnza IP8500 image display terminal. Commercially available, state-of-the-art hardware is defined yielding a cost effective reliable system fully capable of performing the terrain data extraction process.		

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6 January, 1983

SUMMARY

This report describes a design for an interactive image analysis system (IIAS), which implements terrain data extraction techniques, developed by the General Electric Company for the United States Army, Engineer Topographic Laboratories under contract DAAK 70-79-C-0153. The design employs commercially available, state of the art minicomputers and image display devices with proven software to achieve a cost effective, reliable image analysis system. Additionally, the system is fully capable of supporting many generic types of image analysis and data processing, and is modularly expandable to accommodate future processing requirements.

The primary requirements for the IIAS were derived from the terrain data extraction process. This process accepts digitized aerial photography, mosaics several aerial photographs into one map size image, registers the image to a standard map, and classifies terrain characteristics such as forest canopy coverage, average number of stems per hectare, and average stem diameter. The output of the process is a set of polygons that define classified regions on the map. The polygons are output on computer compatible tapes (CCTs) in a format that is compatible with ETL's Terrain Analysis Synthesis System (TASS). In addition to the terrain data extraction requirements, flexibility and expansion potential were key design criteria.

The analysis shows that a Digital Equipment Company VAX 11/750 minicomputer system and a DeAnza IP8500 image display terminal provide the hardware base for a system that meets all requirements in a cost effective

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manner. System reliability and maintainability are enhanced by limiting the system to two vendors using only proven hardware and operating system level software. System flexibility is enhanced with the wide range of standard products, both hardware and software, available for the recommended configuration. Finally, the task of implementing the terrain data extraction software is simplified by the inherent commonality between the recommended VAX based system and the system on which the software was developed (General Electric's DIAL facility).

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PREFACE

This document is generated under Contract DAAK 70-79-C-0153 for the U.S. Army Engineer Topographic Laboratories, Fort Belvoir, Virginia 22060 by the General Electric Space System Division, Lanham, Maryland 20706. The Contracting Officers' Representative was Mr. Homer Babcock.

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CHAPTER 1  
INTRODUCTION

This report describes a design for an interactive image analysis system (IIAS) which implements terrain data extraction techniques developed by the General Electric Company for the United States Army, Engineer Topographic Laboratories under contract DAAK 70-79-C-0153. The design employs commercially available, state of the art minicomputers and image display devices with proven software to achieve a cost effective, reliable image analysis system. Additionally, the system is fully capable of supporting many generic types of image analysis and data processing, and is modularly expandable to accomodate future processing requirements.

The primary requirements for the IIAS were derived from the terrain data extraction process. This process accepts digitized aerial photography, mosaics several aerial photographs into one map size image, registers the image to a standard map, and classifies terrain characteristics such as forest canopy coverage, average number of stems per hectare, and average stem diameter. The output of the process is a set of polygons that define classified regions on the map. The polygons are output on computer compatible tapes (CCTs) in a

## INTRODUCTION

format that is compatible with ETL's Terrain Analysis Synthesis System (TASS).

A conceptual design of the terrain data extraction process and a decomposition of that process into system requirements will be presented in chapter 2. Chapter 3 will compare several potential hardware configurations that are capable of satisfying the stated requirements and recommend an optimal configuration. Chapter 4 will address software considerations, and finally, chapter 5 will outline the implementation of such a system.

## CHAPTER 2

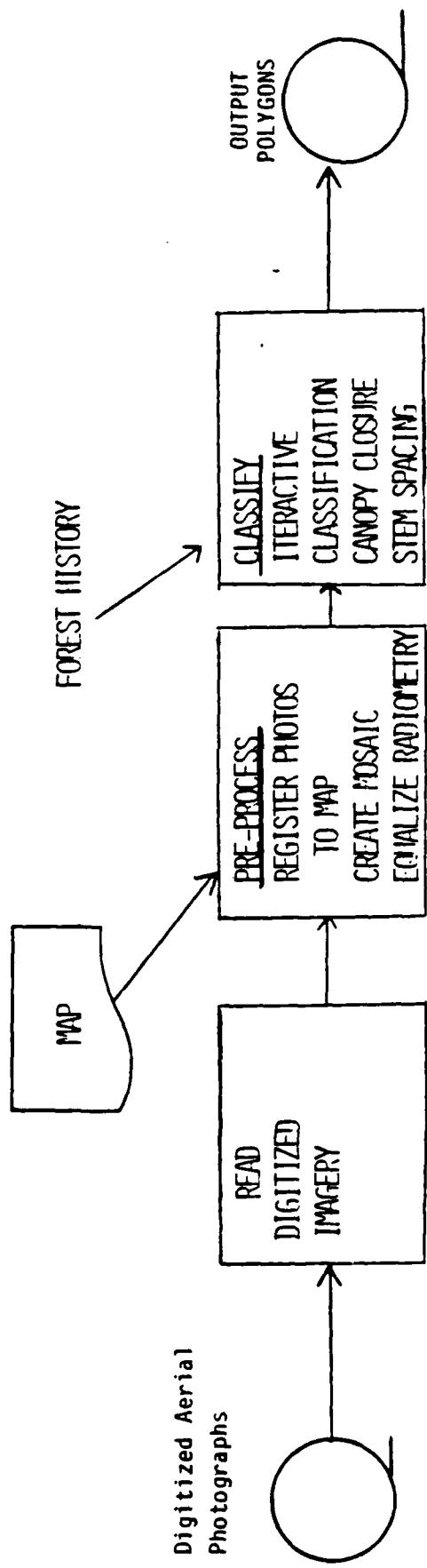
### SYSTEM REQUIREMENTS

#### 2.1 TERRAIN DATA EXTRACTION

The objective of terrain data extraction is to determine forest characteristics from panchromatic aerial photographs. Specifically, it classifies areas of forest in terms of canopy coverage, vegetation type, average number of stems per hectare, average stem spacing, and average stem diameter over specific geographic areas (e.g. the area covered by a standard map). This function is accomplished by applying digital image analysis techniques to one or more digitized aerial photographs, producing a list of polygons that define the classified regions. The process includes registration of digitized aerial photographs to maps, classification of forest regions, and scaling and mosaicking the areas. This is performed by a discipline oriented image analyst using image processing tools and techniques developed by the General Electric Company, under contract to ETL. The Terrain Data Extraction process is illustrated in figure 2-1 and described in detail below.

SYSTEM REQUIREMENTS  
TERRAIN DATA EXTRACTION

TERRAIN DATA EXTRACTION



- ETL will provide digital images (monochrome) on CCT
  - Use control points to register images to map
  - Control points in overlap regions used heavily
  - elevation data required (all views may not be nadir.)
  - Equalize radiometry between images
  - Output-1  $12\text{Km}^2$  image (1 m pixels) registered to the map
- Typically 9, 5000 x 5000 pixel images per map
- Image data stored on disk
- Analyst selects display areas and processing techniques
  - Generate Polygons
  - Output polygons
- Scaling
  - Texture image generation
- Classification
  - Skeletonizing
  - Theme Smoothing
  - Outline Themes
  - Annotation

Figure 2-1

SYSTEM REQUIREMENTS  
TERRAIN DATA EXTRACTION

2.1.1 Ingest Aerial Photography.

Digitized aerial photography shall be available to the IIAS in the form of computer compatible tapes (CCTs). These CCTs are produced by a currently operational digitizing system at the Engineer Topographic Laboratories, and contain aerial photographs digitized to a resolution of approximately one meter. Low altitude aerial photography covering approximately five kilometer square frames is expected to be used most frequently, although IIAS shall be capable of operating on any panchromatic aerial photography digitized to one meter. The format of the input CCT shall be defined by ETL.

IIAS shall read CCTs containing digitized images and store the data on disk in a standard format, suitable for image analysis. The system shall be capable of storing at least nine 5000 by 5000 pixel images on disk simultaneously.

2.1.2 Preprocessing

Preprocessing accepts one or more input images on disk and produces a single consistent image registered to a standard map. In the typical situation, when more than one image is required to cover a map, the process includes mosaicking, scaling, and radiometric equalization of the input images.

SYSTEM REQUIREMENTS  
TERRAIN DATA EXTRACTION

The system registers individual or sets of input images to a standard map by measuring distortions in the input images using control points. Control points are features which are easily identified in the images and on standard maps. Given the geodetic location and elevation (used to compute view angle) of control points from the maps, geometric correction functions are calculated and applied to the input images, creating images that can be accurately overlaid onto the map. At least three spatially distributed control points per image are required. Control points are selected by the image analyst by viewing subsegments of the scene on the image display station and designating points with the trackball and cursor.

When registering several input images to a map, the image analyst selects control points in the overlap regions of adjacent images, facilitating mosaicking of images. In the event that overlap regions between images do not contain suitable control points, a greater number of control points in each image may be required to achieve mosaicking.

The image analyst directs the mosaicking operation, producing one large image representing the entire map. The operation consists of insuring the images line up properly and that the radiometry among the images mosaicked is consistent. Mosaicking adjusts for offsets, scale and view angle differences, and misregistration. The process also equalizes as much as possible the radiometric differences between images acquired at different times. Radiometric equalization is essential to accurate vegetation classification over large areas.

SYSTEM REQUIREMENTS  
TERRAIN DATA EXTRACTION

2.1.3 Classification

Classification is a highly interactive process in which an intelligent, discipline-oriented analyst uses a set of image analysis routines to spatially classify regions of an image. This includes:

1. Generation of derived images via texture operators (micro texture and crown template) and density slicing. Several derived images may be generated for the input image and stored on disk for later analysis.
2. Training site designation. The operator will select small regions of the entire region to analyze in detail. Operations performed on these small regions may then be applied to the entire image in a batch processing mode. Sites are selected by enclosing areas of a subsampled image with a rectangular cursor or by outlining the area with a polygon.
3. Signature extraction. Operating on small image segments, the image analyst generates image statistics and views themes calculated from sets of pixels with similar, analyst defined statistics. Signatures for various target terrain classes are identified.
4. Classification. Signatures extracted from small image segments are applied to the entire image, generating classification maps.

SYSTEM REQUIREMENTS  
TERRAIN DATA EXTRACTION

5. Skeletonizing. Theme skeletons are generated by applying operators (e.g., Golay) to raw theme data.
6. Theme smoothing. Filters are applied to the theme skeletons to remove small islands and to connect disjoint theme skeletons.
7. Theme outlining.
8. Annotation. Annotation can be overlaid on the image and theme data to identify the resultant classification.

2.1.4 Output

Output of the terrain data extraction process is a set of polygons that define classified regions. The polygons are in a format capable of being processed by ETL's Terrain Analysis and Synthesis System.

Polygons are computed automatically from theme maps generated in the classification process. They are defined by a geodetic reference, a closed sequence of vectors, and a classification code defining the vegetation and terrain type. All polygons associated with a single standard map shall be output to a single CCT.

SYSTEM REQUIREMENTS  
TERRAIN DATA EXTRACTION SYSTEM REQUIREMENTS

2.2 TERRAIN DATA EXTRACTION SYSTEM REQUIREMENTS

Basic system requirements for IIAS can be derived through analysis of each of the above terrain data extraction functions. These requirements fall into five basic categories: host computer input/output, host computer computation, image display, memory system, and other capabilities. Table 2-1 illustrates the requirements of each terrain data extraction function in these categories. The following paragraphs describe the derivation of table 2-1.

2.2.1 Read Digitized Images

During the ingest of raw images, the host computer simply transfers data from magnetic tape to disk. The host computer input/output rate is determined by the tape input rate, which is calculated as follows:

Assume 5000 pixel blocks, one byte per pixel, 1600 bpi tapes,  
125 ips tape drives, .75 inter-record gap.

Transfer rate = 5000 pix/record \* 125 ips

-----  
(5000 pix/1600 bpi + .75 irg)/record

= 165 K bytes/second

Aggregate I/O rate = 165 KB/sec (tape) + 165 KB/sec (disk) = 330 KB/sec

SYSTEM REQUIREMENTS  
TERRAIN DATA EXTRACTION SYSTEM REQUIREMENTS

Table 2-1. Terrain Data Extraction Processing Requirements  
(Page 1 of 2)

FUNCTION	HOST CPU		IMAGE DISPLAY	MEMORY SYSTEM	OTHER
	I/O	COMPUTATION			
READ DIGITIZED IMAGES 9 5000 X 5000 PIXEL	330 KB/SEC TAPE $\rightarrow$ DISK	NEGLIGIBLE	—	225 MBYTES	1600, 125 IPS TAPE DRIVE
IMAGES ON MAGNETIC TAPES					
PREPROCESS IMAGERY					
SELECT CONTROL POINTS	260 KB/SEC DISK $\rightarrow$ DISPLAY	< DISK $\rightarrow$ DISPLAY	DISPLAY IMAGE ZOOM, TRACKBALL CURSOR CONTROL	<	OPERATOR DEPENDENT (1 MIN POINT)
COMPUTE GEOMETRIC CORRECTION FUNCTION (PER IMAGE)	260 KB/SEC DISK $\rightarrow$ DISPLAY	30 SEC	—	<	
DETERMINE IMAGE STITCHING PARAMETERS (PER PAIR)	260 KB/SEC DISK $\rightarrow$ DISPLAY	15 SEC/PAIR AFTER OPERATOR INTERACTION	DISPLAY IMAGE, IMAGE OVERLAY, ARITHMETIC IMAGE COMBINATION	<	OPERATOR DEPENDENT,
EQUALIZE RADIOMETRY	260 KB/SEC DISK $\rightarrow$ DISPLAY	2 MIN/512 <sup>2</sup> SEGMENT	DISPLAY IMAGE, HISTOGRAMMING, ARITHMETIC COMBINATION	<	OPERATOR DEPENDENT, GRAPHIC TERMINAL
RESAMPLE (NEAREST NEIGHBOR) AND ADJUST RADIOMETRY	600 KB/SEC DISK $\rightarrow$ DISK	400 KBYTES MAIN MEMORY, 20 MIN/IMAGE (~1.64 SEC CYCLE TIME)		144 MBYTES OUTPUT + 255 MBYTES INPUT	

Table 2-1. Terrain Data Extraction Processing Requirements  
(Page 2 of 2)

SYSTEM REQUIREMENTS  
TERRAIN DATA EXTRACTION SYSTEM REQUIREMENTS

The memory system storage requirement is based on nine 5000 by 5000 pixel images (225 MBytes).

Other requirements include 1600 bpi (as required by TASS) and 125 ips tape drives. 125 ips tape drives allow images to be read in approximately 2.5 minutes. Slower tape drives (75 ips or 45 ips) may be used, but will slow down the input process.

### 2.2.2 Preprocess Imagery

#### 2.2.2.1 Select Control Points. -

Control point selection is performed almost entirely by the image analyst. The IIAS must display subsampled, full resolution, zoomed images, and allow the operator to designate control points with the cursor. The only requirement on the host computer is the ability to fill the image display screen in 2 seconds, which requires an I/O rate of:

$$512 \text{ pixels} * 512 \text{ lines} / 2 \text{ seconds} * 2 \text{ devices (in and out)} = 264 \text{ KB/sec.}$$

Requirements on the image display include the ability to display 512 by 512 pixel image segments, the ability to move a cursor using a trackball, and the ability to read the position of the cursor.

## SYSTEM REQUIREMENTS

### TERRAIN DATA EXTRACTION SYSTEM REQUIREMENTS

#### 2.2.2.2 Compute Geometric Transfer Function -

This function is performed by the host computer and requires moderate computation on a relatively small data set. Currently, the GE DIAL system is capable of performing this operation in less than 30 seconds per image, which is judged acceptable.

#### 2.2.2.3 Determine Image Stitching Parameters -

This function is highly interactive and requires display of two images at the image display terminal and moderate computation in the host computer. The host computer I/O requirement is 264 KB/sec (disk to image display) as calculated above. Computations must be performed at 15 seconds per image pair.

The image display device must locally store four 512 by 512 images, have the capability of overlaying and arithmetically combining those images.

#### 2.2.2.4 Equalize Radiometry -

The radiometry of different input images is equalized by analyzing histograms of the images (especially the overlap regions between images) and evaluating different radiometric transformations of the images using radiometric look-up tables in the image analysis device. The host computer requirements include an I/O rate of 264 KB/sec and the ability to generate radiometric look-up tables. Residual mosaic seams are removed by filtering techniques.

SYSTEM REQUIREMENTS  
TERRAIN DATA EXTRACTION SYSTEM REQUIREMENTS

The image display device must:

1. Locally store and display four images.
2. Use a rectangular, rubber band type cursor to designate analysis areas.
3. Use a tracking cursor to designate mosaic splice lines.
4. Generate histograms for analysis area.
5. Apply radiometric look-up tables.

2.2.2.5 Create Full Map, Registered Image. -

Full map registered images are produced by using nearest neighbor resampling and applying radiometric look-up tables to an input image creating an output image. This function is performed entirely in the host computer and involves a disk to disk transfer with intermediate computations. The volume requirements are calculated as follows:

Input image = 225 MByte

Output image = 1 meter square pixels \* 12 Km square maps = 144 MByte

Total memory required = 225 MB + 144 MB = 369 MBytes

The host computer requirements are based on disk to disk transfer rates. Sustained disk transfer rates of 600 KBytes/sec are achievable with many disk technologies and are therefore required.

SYSTEM REQUIREMENTS  
TERRAIN DATA EXTRACTION SYSTEM REQUIREMENTS

The computation time required to accomplish resampling and radiometric look-up should not exceed the disk transfer time. Assuming adequate buffering is provided, the resampling process is therefore I/O bound and not computation bound. The total time for the transfer of one image is calculated as follows:

Assume a single disk is used, 600KB/sec transfer rate, 35 msec average access time.

Transfer time for 50 KB blocks=

(35 msec access + 50KB / 600 KB/sec) * 369 MB / 50 KB	= 870.9 sec
	= 15 min
with 50% margin for error	= 22.5 min

Transfer time for 5 KB blocks=

(35 msec access + 5KB / 600 KB/sec) * 369 MB / 5 KB	= 3198 sec
	= 53 min
with 50% margin for error	= 80 min

In addition to defining the processing requirement of 22.5 minutes for resampling and performing radiometric translation, the above calculations define a requirement for large buffer areas in programs. Assuming that three input buffers and three output buffers are required at one time, 300 KB of main program memory are required for buffers alone. A total directly addressable program space of 500 KB is therefore required. This requirement disqualifies most 16 bit minicomputers as host machines.

SYSTEM REQUIREMENTS  
TERRAIN DATA EXTRACTION SYSTEM REQUIREMENTS

2.2.3 Classification

2.2.3.1 Generation Of Derived Images Via Texture Operators -

Generation of texture image involves passing a three by three operator over the target image area. GE DIAL experience with this function indicates that 30 seconds per 512 pixel square image is reasonable and acceptable. Image manipulations can be greatly enhanced if a full input and output 512 by 512 pixel can be stored and addressed in main memory. This implies a requirement of at least 512 KBytes of directly addressable array space in one program. Therefore, the requirement of at least one MByte of directly addressable main memory in the host computer is imposed.

2.2.3.2 Training Site Designation -

Training site designation requires disk to image display data transfers (at 264 KB/sec) from the host computer and rectangular rubberbanding cursor control at the image display console. Graphic overlays at the image display device are also required for polygon displays.

2.2.3.3 Signature Extraction -

This function involves statistical evaluation of image data. The host computer is required to display image data (264 KB/sec), calculate two dimensional histograms, and display statistics on a graphics terminal. Computation times, based on GE DIAL experience,

SYSTEM REQUIREMENTS  
TERRAIN DATA EXTRACTION SYSTEM REQUIREMENTS

should not exceed 30 seconds per two dimensional histogram. A graphic CRT, independent from the image display, having a resolution of 512 by 512 pixels is required. A cross hair cursor on the graphic terminal is also required.

The image display device must support full resolution image overlays, up to four theme (graphic) overlays, switching of image memories to different color outputs, histograms, and arithmetic combinations of image memories. Any intermediate images created by the image display device must be accessible by the host computer.

2.2.3.4 Classification -

Classification requires disk to image display device I/O (264 M/sec) and disk to disk I/O with intermediate computations (such as filtering). The host computer computational requirements for this process are similar to those for signature extraction.

2.2.3.5 Skeletonizing -

Application of Golay and similar operators requires varying amounts of computer resources. Based on different algorithms used, processing times vary between 30 seconds and 10 minutes per 512 pixel square image segments.

SYSTEM REQUIREMENTS  
TERRAIN DATA EXTRACTION SYSTEM REQUIREMENTS

2.2.3.6 Theme Smoothing -

Theme smoothing requires the application of various filters to image data. GE DIAL experience indicates that one minute processing times for 512 by 512 image segments is adequate.

2.2.3.7 Theme Outlining -

GE DIAL experience shows that 30 seconds per 512 by 512 image segment is reasonable for this process.

2.2.3.8 Annotation -

Overlaying text onto image data in the image display device is neither I/O nor computationally intensive.

2.2.4 Output Processing.

Generation of polygons from classification maps is a batch process, and as such does not require extremely fast processing. Generation of polygons for the entire image should take no more than 30 minutes, and only disk to disk and disk to tape I/O are required (500KB/sec).

2.3 ADDITIONAL CONSIDERATIONS

In addition to the performance requirements stated above, system integration, reliability, maintainability, expansion potential requirements, and ease of use are appropriate. These are as follows:

SYSTEM REQUIREMENTS  
ADDITIONAL CONSIDERATIONS

2.3.1 System Integration

The system integration effort can be greatly facilitated by selecting system components that fit together easily. In general, special hardware and/or software interfaces between system components are costly and introduce many integration problems. It is therefore required that the hardware interface between the selected host computer and image display device, and the software device driver for the image display device must be standard products of either the host computer vendor or the image display device vendor.

System integration efforts, as well as system maintenance at a later time, are also enhanced by minimizing the number of hardware vendors. It is therefore highly desirable that the host computer vendor supply and offer maintenance contracts for the disk memory system, magnetic tape system, and graphic display system, as well as the computer.

2.3.2 Reliability And Maintainability

System life cycle costs depend greatly on reliability and maintainability. These factors are enhanced by selecting only commercially available, "off the shelf" hardware, selecting vendors with local service representatives, avoiding customized hardware and system software, and if possible, evaluating the service record of the vendors.

SYSTEM REQUIREMENTS  
ADDITIONAL CONSIDERATIONS

Limiting the number of vendors also enhances reliability and maintainability. Since none of the computer vendors surveyed offer image analysis devices, two vendors is the minimal and optimal number of different hardware vendors. It is highly desirable for the image display device vendor to be very familiar with the selected host computer. This familiarity facilitates the identification and resolution of system level problems.

#### 2.3.3 Expansion Potential

The IIAS is required to be capable of performing, or gracefully expanding to perform, future image processing functions at ETL. These functions may include complex geometric corrections on aerial photography, map generation, program development, and film product generation. In order to support these functions, the IIAS is required to support multi-tasking, program development, and addition of high speed I/O devices such as array processors, high resolution film recorders, additional disks, and hard copy plotters.

Specific requirements on the host computer include the following:

1. The ability to perform additional functions such as program development and batch processing without significantly hindering the terrain data extraction process. This requires sufficient main memory, disk space (or expansion capability), and input/output bandwidth for terrain data extraction and other development. Currently, 1 MByte main memory, 450 MByte of disk space, and an aggregate thruput of 1.2 MBytes/sec is

SYSTEM REQUIREMENTS  
ADDITIONAL CONSIDERATIONS

considered minimally acceptable.

2. The ability to support at least eight direct memory access devices. Initially the system must support: disk controller(s), a tape controller, communications controller, and an image analysis device. Expansion potential for an array processor, high resolution film recorder, plotter, and one spare channel must exist.
3. A flexible, mature software development environment is required to support program development.
4. Software transportability to a larger, more capable machine is desirable.

2.3.4 Ease Of Use

Ease of use is an important design criteria since it can significantly impact the productivity of future work and can enhance the reliability of the system. Unfortunately, measures of ease of use are mostly subjective in nature and many times reflect only the personal preferences of the evaluator rather than measurable factors. In this evaluation, ease of use will be judged based on the number and types of software packages applicable to the TIAS available for use for the machine in question. It is recognized that volume is not necessarily a measure of quality, however :

SYSTEM REQUIREMENTS  
ADDITIONAL CONSIDERATIONS

1. Large software libraries probably indicate a large user community familiar and comfortable with using the machine in question for similar functions.
2. Large software libraries are generally more mature, containing fewer problems and easier to use interfaces.
3. Existing software libraries are better than no libraries at all.
4. Finally, detailed evaluations to determine ease of use are outside the scope of this report.

## CHAPTER 3

### HARDWARE

A basic block diagram of the IIAS is illustrated in figure 3-1. It consists of a host computer system (minicomputer, memory system and input/output system) and an image display device. The following section compares host computer systems and image display devices from several different vendors on the basis of the requirements stated in chapter 2 and cost.

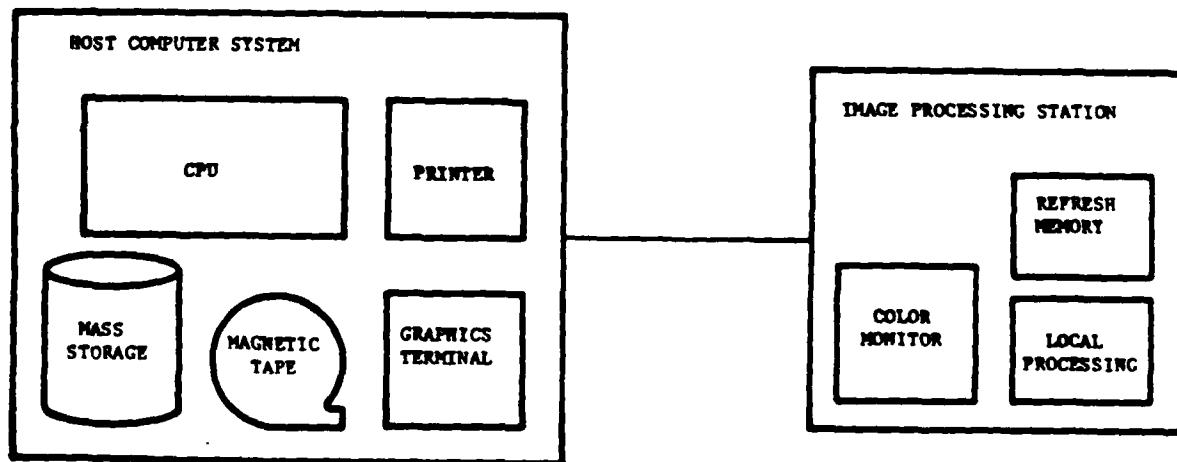


Figure 3-1. Interactive Image Analysis System Block Diagram

HARDWARE  
HOST COMPUTER

3.1 HOST COMPUTER

The host computer provides the input/output function, image storage, operator interface, and computational power of IIAS. The key requirement for the host computer is the ability to store and directly access large arrays of image data in memory. Since the addressing space of most 16 bit minicomputers is limited to 64 Kbytes, 16 bit machines must support a dynamic memory mapping system to meet requirements. In general, 32 bit minicomputers are better suited to the IIAS application. Based on this requirement, 12 potential host computer vendors were surveyed including:

1. Digital Equipment Corporation (VAX 11/730 and 11/750)
2. Hewlett Packard (HP 1000 series, F models and the new A-900)
3. Prime (550 II)
4. Perkin Elmer (3210)
5. Data General (Eclipse MV 4000)
6. General Automation (GA16-470)
7. Honeywell Information Systems (6/53)
8. Modcomp (Classic 7870)
9. Gould (S.E.L., Concept 32/87)
10. Univac (V77)
11. Harris (AN-UYK-62)
12. IBM (4331)

HARDWARE  
HOST COMPUTER

The host computer selection is based on a set of minimally acceptable requirements and a set of desirable features. Any system not meeting all minimum requirements is eliminated from the selection. Capacity in excess of the stated minimum requirement is only considered an asset if it is applicable to some desirable feature (e.g., expansion potential). After minimum requirements are satisfied, preliminary cost estimates are prepared. Any systems not within 20 percent of the lowest cost system are eliminated. Desirable features are then compared and a single system selected.

Table 3-1 illustrates minimum requirements and desirable features for each potential host computer system. All processing requirements stated in chapter 2 are not directly represented on this table due to data and time limitations. Specifically, processing time requirements are difficult to evaluate without representative benchmark programs (which were outside the scope of this analysis). Comparisons based on raw computer cycle times can be very deceiving, especially in considering the effects of cache memory, dynamic memory mapping systems (in 16 bit machines), and the software environment. In terms of computational speed, all 12 systems are considered acceptable. This is based on the computation power of the GE DIAL system (implemented on a PDP 11/35).

From table 3-1, the General Automation and Honeywell systems can be eliminated on the basis of requiring special interface hardware for image analysis terminals. Prime, Perkin-Elmer, and Univac can be eliminated on the basis of cost. Since the evaluation of the

HARDWARE  
HOST COMPUTER

TABLE 3-1  
HOST COMPUTER COMPARISON

FEATURE	1145	3270	4470	4470	PRIME	DECIM- ITL 1000	DATA GENERAL SIGNAL AUTOMATION	MONEYWELL INFO. SYS.	HOST COMP.	CHILO SEC.	UNIVAC	MARKS	IBM
MINIMUM REQUIREMENT	VAX 11/750	VAX 11/750	HP 1000 (P)	A-900	SSO 11	1.80	MV 4000	GA16-470	6153	2860	UNICP	7171-500	4311
MEMORY CAPACITY	5 MBYTE	5 MBYTE	7 MBYTE	6 MBYTE	16 MBYTE	8 MBYTE	2 MBYTE	2 MBYTE	4 MBYTE	16 MBYTE	2 MBYTE	12 MB	4 MBYTE
ADDRESSING	1 WORD	4, 1 BYTE	2 WORD	4, 1 BYTE	16 BYTE	2 BYTE	1 BYTE	1 BYTE	1 BYTE	16 BYTE	2 MBYTE	12 MB	4 MBYTE
AVERAGE INSTRUCTION CYCLE TIME	1.05 NSEC	1.05 NSEC	1.05 NSEC	1.05 NSEC	1.05 NSEC	1.05 NSEC	1.05 NSEC	1.05 NSEC	1.05 NSEC	2.00 NSEC	1.05 NSEC	1.05 NSEC	1.05 NSEC
MEMORY CYCLE TIME	1.05 NSEC	1.05 NSEC	1.05 NSEC	1.05 NSEC	1.05 NSEC	1.05 NSEC	1.05 NSEC	1.05 NSEC	1.05 NSEC	2.00 NSEC	1.05 NSEC	1.05 NSEC	1.05 NSEC
HIGH PERFORMANCE PRINTW. PT	OPTIONAL	OPTIONAL	STANDARD	STANDARD	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	OPTIONAL	NO	STANDARD
I/O SYSTEM													
AGGREGATE RATE	1.5 MB/SEC	1.5 MB/SEC	2.6 MB/SEC	NA	2.5 MB/SEC	1.5 MB/SEC	2.2 MB/SEC	6 MB/SEC	3.6 MB/SEC	2.7 MB/SEC	1 MB/SEC	1.9 MB/SEC	1.7 MB/SEC
DISK CAPACITY	1.01 MB	1.14 MB	1.16 MB	1.16 MB	1.4 MB	1.4 MB	1.6 MB	1.6 MB	1.6 MB	1.2 MB	1.2 MB	1.2 MB	1.2 MB
DISK RATE	1.5 MB/SEC	2.0 MB/SEC	1.9 MB/SEC	1.9 MB/SEC	1.2 MB/SEC	1.2 MB/SEC	1.2 MB/SEC	1.2 MB/SEC	1.2 MB/SEC	1.2 MB/SEC	700 KB/SEC	700 KB/SEC	1.0 MB/SEC
DDMA DEVICES	8	22	28	24	24	26	22	5	23	63	66	40	-
PERIPHERAL DEVICES	8	20	>20	>	>	>	>	64	16	>	>	>	-
TAPE DENSITY	1640	1640/1640/1640	1640/1640	1640/1640	1640/1640	1640/1640	1640/1640	1640/1640	1640/1640	800/1600	800/1600	800/1600	800/1600
TAPE SPEED	1.5 IPS	1.5 IPS	1.5 IPS	1.5 IPS	1.5 IPS	1.5 IPS	1.5 IPS	1.5 IPS	1.5 IPS	1.5 IPS	1.5 IPS	1.5 IPS	1.5 IPS
SOFTWARE													
MULTITASKING, I/E/F/F	4	9	9	YES	YES	118	115	64	YES	15	YES	YES	YES
HIGH LEVEL LANG. ACP	FORTRAN	FORTRAN	FORTRAN	FORTRAN	FORTRAN	FORTRAN	FORTRAN	FORTRAN	FORTRAN	FORTRAN	FORTRAN	FORTRAN	FORTRAN
GRAPHICS PACKAGE	BLI	BLI	BLI	BLI	BLI	BLI	BLI	BLI	BLI	BLI	BLI	BLI	BLI
ENVIRONMENT	EXCELLENT	EXCELLENT	-	-	-	-	-	-	-	-	-	-	-
EXPANSION POTENTIAL													
SUBJECTIVE ESTIMATE	FATH	1.4PD	LIMITED	EXCELLENT	EXCELLENT	EXCELLENT	EXCELLENT	EXCELLENT	EXCELLENT	EXCELLENT	EXCELLENT	EXCELLENT	EXCELLENT
SOFTWARE TRANSPORTABILITY	1.4PD	1.4PD	1.4PD	1.4PD	1.4PD	1.4PD	1.4PD	1.4PD	1.4PD	1.4PD	1.4PD	1.4PD	1.4PD
VERT RELATIVE	11/1750	11/1750	1.8M	1.8M	1.8M	1.8M	1.8M	1.8M	1.8M	1.8M	1.8M	1.8M	1.8M
SERVICE													
REPRESENTATION	1.4PD	1.4PD	1.4PD	1.4PD	1.4PD	1.4PD	1.4PD	1.4PD	1.4PD	1.4PD	1.4PD	1.4PD	1.4PD
ALL HW IN ONE CONTRACT	EXCEPT TAPE DRIVE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
SPECIAL HW	None	None	None	None	None	None	None	None	None	None	None	None	None
ACCEPTABLE COST	11/1750	11/1750	1.8M	1.8M	1.8M	1.8M	1.8M	1.8M	1.8M	1.8M	1.8M	1.8M	1.8M

IA - INFORMATION NOT AVAILABLE

\*NOTE: ADDRESSING BEYOND 64 BYTES REQUIRES  
OPTIONAL DYNAMIC ADDRESSING. SYSTEM  
OPERATION UNCHANGED DURING THE BASIC  
OPERATION. PRICE.

remaining seven vendors depends on evaluation of desirable features, which are discussed in the recommendation section.

### 3.2 IMAGE ANALYSIS

The functional requirements for the image display device listed in table 2-1 lead to the following minimal performance requirements:

1. 512 by 512 pixel display. Typical image display devices offer 512 by 512 or 1024 by 1024 pixel resolution. The former is selected, since it considerably reduces the memory (and thereby the cost) of the device. Neither resolution is sufficient to display a full map size image without resampling, therefore operations on image segments is necessary with either.
2. Refresh memory for four 512 pixel by 512 pixel by eight bit images. This requirement is derived from the requirement to perform real time combinations of the base image and derived images.
3. Output resolution of 256 levels per red, green and blue color. The device is required to display the basic radiometric resolution of the imagery on each color gun.
4. Four graphic overlay channels. Graphic overlay channels are used for theme overlays, annotation, and training area designation.

HARDWARE  
IMAGE ANALYSIS

5. Matrix color assignment. The device is required to allow convenient assignment of any of the four refresh memories to any of the three color outputs.
6. Image combinations. Efficient image analysis requires the real time arithmetic combination of images in refresh memory. Addition and subtraction are minimally required.
7. Histogramming. Many statistical measurements for signature analysis require histogramming. Histogram generation shall require less than one second.
8. Radiometric look-up tables. Radiometric look-up tables per color are required for interactive radiometric equalization.
9. Feedback loop. Image combinations must be capable of being stored in refresh memory, available for transmission to the host and display.
10. Window cursor. Training area designation requires a rubber-band type rectangular cursor.
11. Transfer rate of 200 KB/sec. This rate is required to fill the display in less than two seconds.

Seven image analysis device vendors considered:

1. Comtal (Vision one/20)
2. DeAnza (IP8500)

HARDWARE  
IMAGE ANALYSIS

3. Lexidata (System 3400)
4. Grinnell (GMR 270)
5. Aydin (5216)
6. Ramtek (9400)
7. Genisco (3000)

Table 3-2 illustrates the performance of each of these devices with respect to the IIAS requirements. Equally important as the performance requirements is the ability of the selected image display device to operate with the selected host computer. The ability is indicated by the image display vendor supplying as standard products hardware device interfaces, operating system device drivers, utility (Fortran callable) packages, and/or application software packages. Table 3-3 is a matrix defining image analysis versus host computer standard products.

As indicated in table 3-2, Comtal, DeAnza, Lexidata, and Grinnell image analysis terminals fully meet the stated requirements. The other terminals are primarily upgraded graphic terminals and do not provide the image processing capabilities or flexibilities required.

Each of the four remaining terminals has unique advantages. DeAnza provides hardware interfaces for several host computers and a significant software library for VAX hosts. Comtal offers significantly greater hardware image processing capabilities than either DeAnza or Lexidata; however, the cost of these desirable but not required features is also significant. Lexidata provides hardware and operating system software for several hosts.

Table 3-2. Interactive Image Analysis System Image Display Comparison

	REQUIRED	CONTAL VISION ONE/20	DE ANZA IP8500	LEXIDATA SYSTEM 3400	GRINNELL GMR 270	AYDIN 5216	RANTEK 9400	GENISCO GCT 3000
DISPLAY AREA	512 <sup>2</sup> 15 x 512 <sup>2</sup> x 8 Bit	512 <sup>2</sup> or 1024 <sup>2</sup> 15 x 512 <sup>2</sup> x 8 Bit	512 <sup>2</sup> or 1024 <sup>2</sup> 20 x 512 <sup>2</sup> x 8 Bit	512 <sup>2</sup> or 1024 <sup>2</sup> 5 x 512 <sup>2</sup> x 8 Bit	512 <sup>2</sup> or 1024 <sup>2</sup> 5 x 512 <sup>2</sup> x 8 Bit	512 <sup>2</sup> or 1024 <sup>2</sup> 8 x 512 <sup>2</sup> x 8 Bit	512 <sup>2</sup> or 1024 <sup>2</sup> 8 x 512 <sup>2</sup> x 16 Bit	512 <sup>2</sup> or 1024 <sup>2</sup> 8 x 512 <sup>2</sup> x 8 Bit
REFRESH MEMORY	4	8	8	5	5	4	8	4
GRAPHIC OVERLAY								
OUTPUT (DAC)	8 bit, 3 color	8 bit, 3 color	8 bit, 3 color	8 bit, 3 color	8 bit, 3 color	8 bit, 3 color	8 bit, 3 color	8 bit, 3 color
TRUE AND PSEUDO COLOR	Matrix	Matrix	Matrix	Matrix	Matrix	Matrix	Matrix	Matrix
HISTOGRAMMING	< 1 Sec	Real-Time	Real-Time	Real-Time	Real-Time	Real-Time	Software	No
LOOK UP TABLES	Per Color	Per Channel	Per Color	Per Color	Per Color	Per Color	Per Color	Per Color
IMAGE COMBINATION	+, -, *	+, -, *, More Compare	+, -, *, -	+,-, *, - AND	+,-, *, - AND	Software	Yes	No
FEEDBACK LOOP	Yes	Yes	Yes	Yes	No	No	No	No
CURSOR	Window	Window	Window	Quad	Graphic	Graphic	Graphic	Graphic
TRANSFER RATE	200 KB/Sec	1500 KB/Sec	2000 KB/Sec	NA	1000 KB/Sec	NA	300 KB	
INPUT	Trackball, Joystick	TB, JS	TB, JS	TB, JS	TB, JS	TB, JS	TB, JS	
EXPANSION POTENTIAL	Excellent	Good	Fair	Fair	Poor	Poor	Poor	
GRAPHIC CAPABILITY	Yes	No	Yes	No	Yes	Yes	Yes	

HARDWARE  
RECOMMENDATIONS

Table 3-3. Host Computer - Image Analysis Device Support Matrix

HOST COMPUTER		IMAGE ANALYSIS SUPPORT									
		GENERAL		GENERAL AUTOMATION		BONWESELL INFO.		MODCOGP		GOLDEN S21	
PERKIN-ELMER		PRIME		HEWLETT-PACKARD		DIGITAL EQUIPMENT		CONTAL		H/W I/F	
DRIVER	DRIVER	DRIVER	DRIVER	DRIVER	DRIVER	DRIVER	DRIVER	DRIVER	DRIVER	DRIVER	DRIVER
UTILITIES	UTILITIES	UTILITIES	UTILITIES	UTILITIES	UTILITIES	UTILITIES	UTILITIES	UTILITIES	UTILITIES	UTILITIES	UTILITIES
ANALYSIS S/W	ANALYSIS S/W	ANALYSIS S/W	ANALYSIS S/W	ANALYSIS S/W	ANALYSIS S/W	ANALYSIS S/W	ANALYSIS S/W	ANALYSIS S/W	ANALYSIS S/W	ANALYSIS S/W	ANALYSIS S/W
DE ANZA	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
H/W I/F	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
DRIVER	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
UTILITIES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
ANALYSIS S/W	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
LEXI DATA	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
H/W I/F	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
DRIVER	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
UTILITIES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
ANALYSIS S/W	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
GRINNELL	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
H/W I/F	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
DRIVER	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
UTILITIES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
ANALYSIS S/W	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
ADIN											
H/W I/F	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
DRIVER	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
UTILITIES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
ANALYSIS S/W	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
RANTER											
H/W I/F	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
DRIVER	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
UTILITIES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
ANALYSIS S/W	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
COMISCO											
H/W I/F	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
DRIVER											
UTILITIES											
ANALYSIS S/W											

HARDWARE  
RECOMMENDATIONS

3.3 RECOMMENDATIONS

The field of potential host computer vendors can be narrowed to Digital Equipment, Hewlett Packard, and Data General by eliminating all vendors for which Comtal, DeAnza, Lexidata, or Grinnell do not offer standard hardware interfaces and operating system device drivers. The host computer selection therefore becomes a comparison between the Digital Equipment VAX (11/730 or 11/750), Hewlett Packard HP 1000 (F or A900), and Data General MV 4000.

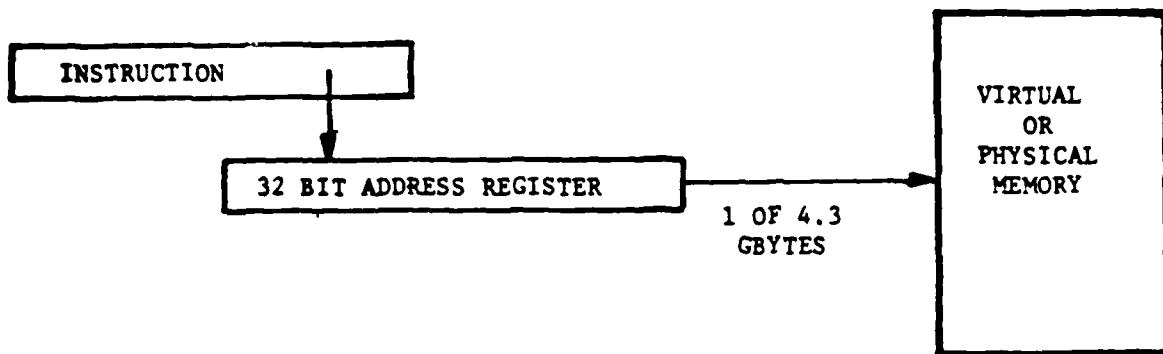
Both the VAX 11/730 and HP 1000 F are capable of supporting terrain data extraction processing, but do not provide as much expansion potential as their larger relatives, the VAX 11/750 and A900. Since the cost difference is less than 15 percent, the VAX 11/730 and HP 1000 F are eliminated.

Comparing the VAX 11/750, MV 4000 and A900 in terms of performance does not produce a clearly superior choice. The A900 performs computations at a higher rate, but the overhead in accessing large arrays (typical in image processing) negates the A900's speed advantage. This overhead is due to the basic 16 bit addressing used in the A900 versus the 32 bit addressing used in the VAX 11/750 and MV 4000. Figure 3-2 illustrates the addressing schemes used in the machines under consideration. The VAX and MV 4000 directly address up to 4.3 GBytes of memory in a single instruction. The A900 uses a memory mapping system where each instruction specifies a 16 bit address. The upper five bits of the address point to one of

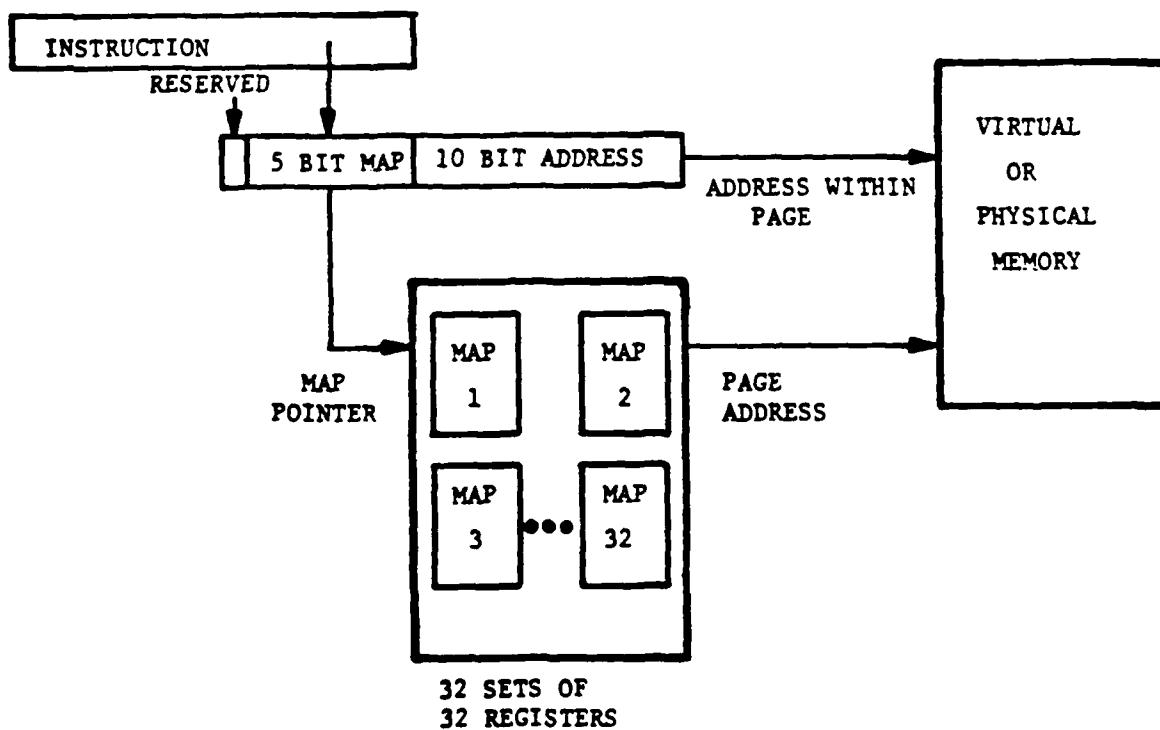
HARDWARE  
RECOMMENDATIONS

Figure 3-2  
ADDRESSING SCHEMES FOR 64K OR LARGER ARRAYS

VAX OR DATA GENERAL (32 BIT MACHINES)



HEWLETT PACKARD A-900



HARDWARE  
RECOMMENDATIONS

32 sets of page address registers. Each set of page address registers contains 32 registers of which one active register specifies the actual memory page addressed. The lower 10 bits of the address specify the address within the page (pages are 1024 words, 2048 bytes). Since a single instruction specifies only the set of map registers and the address within the page--and not the active map register within the set--only 64K bytes can be directly addressed with a single instruction. A second instruction is required to change the active map register for addresses outside of the current 64K map. In image processing, where input and output arrays are likely to be in different maps (due to their large size), each operation of retrieving and storing pixels may require two instructions in the A900 where only one instruction is required in the VAX or MV 4000. Since the A900 system software performs the operation of changing the active map register, these extra operations are transparent to application program development; however, their effect will be visible in system performance.

Reliability, maintainability, system integration, and expansion potential criteria likewise do not separate the two.

The final criteria defined in chapter 2, ease of use, must be employed to determine a recommended system. Based on table 3-3, the commercially available image processing software for the VAX is significantly greater than that available for the A900 or the MV 4000. This indicates that image processing software development will be

## HARDWARE RECOMMENDATIONS

easier for the VAX (due to the existing image processing tools). Furthermore, this situation will tend to extend itself. Since image processing tools are currently more available for the VAX, more people will select VAXs for their image processing host computer, which in turn, will increase the number and quality of the VAX image processing software libraries.

The DeAnza image analysis terminal is recommended on the basis of cost advantages over Comtal, software support over Lexidata, and expansion potential over Grinnell.

Figures 3-3 and 3-4 illustrate the recommended hardware configuration and front elevation respectively. Note that two disk and tape drives have been included. These devices provide a backup capability at a relatively low cost. Table 3.4 completely defines the recommended hardware.

HARDWARE  
RECOMMENDATIONS

ETL HARDWARE CONFIGURATION

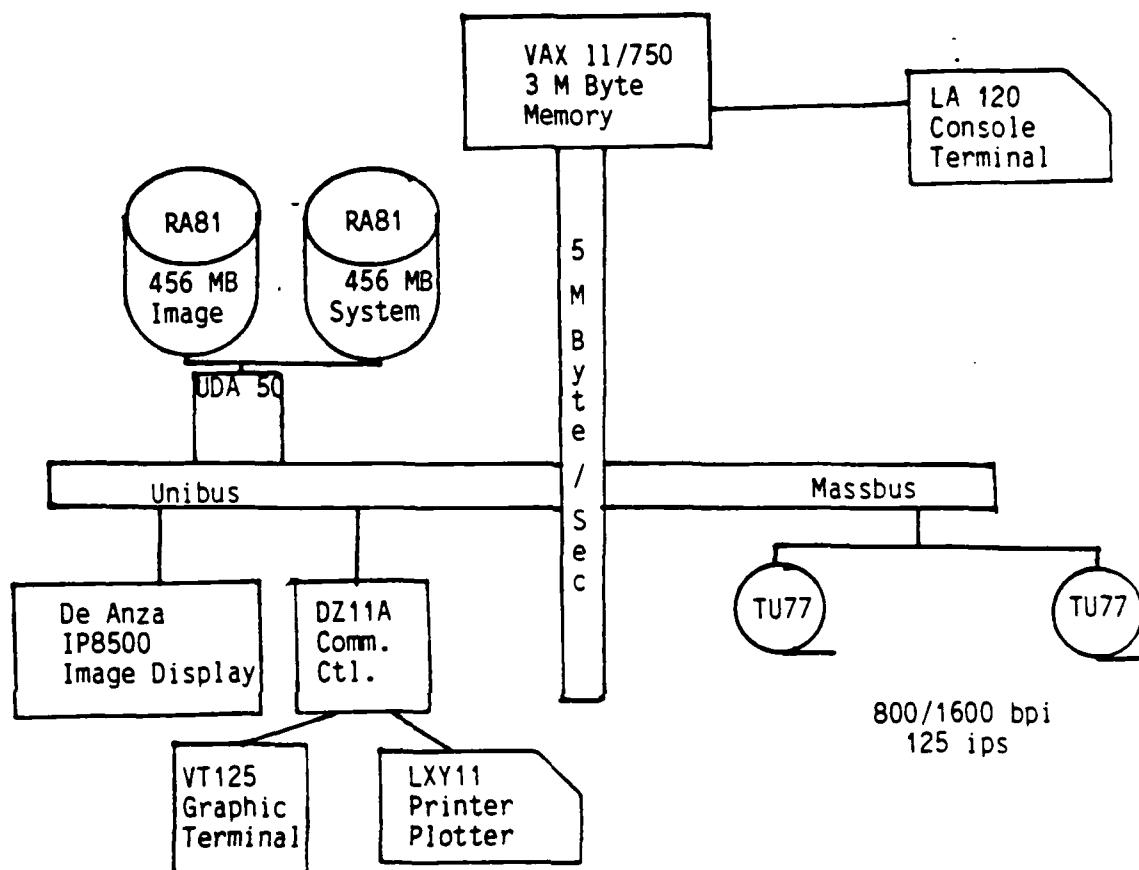


Figure 3-3

INTERACTIVE IMAGE ANALYSIS SYSTEM

FRONT ELEVATION

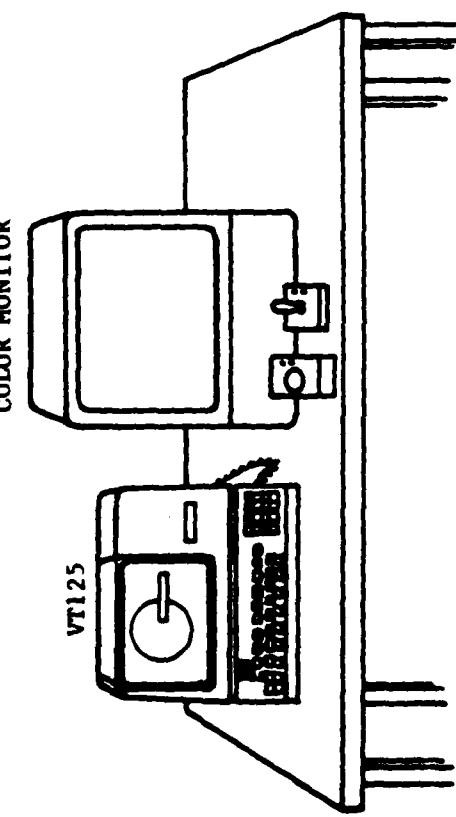
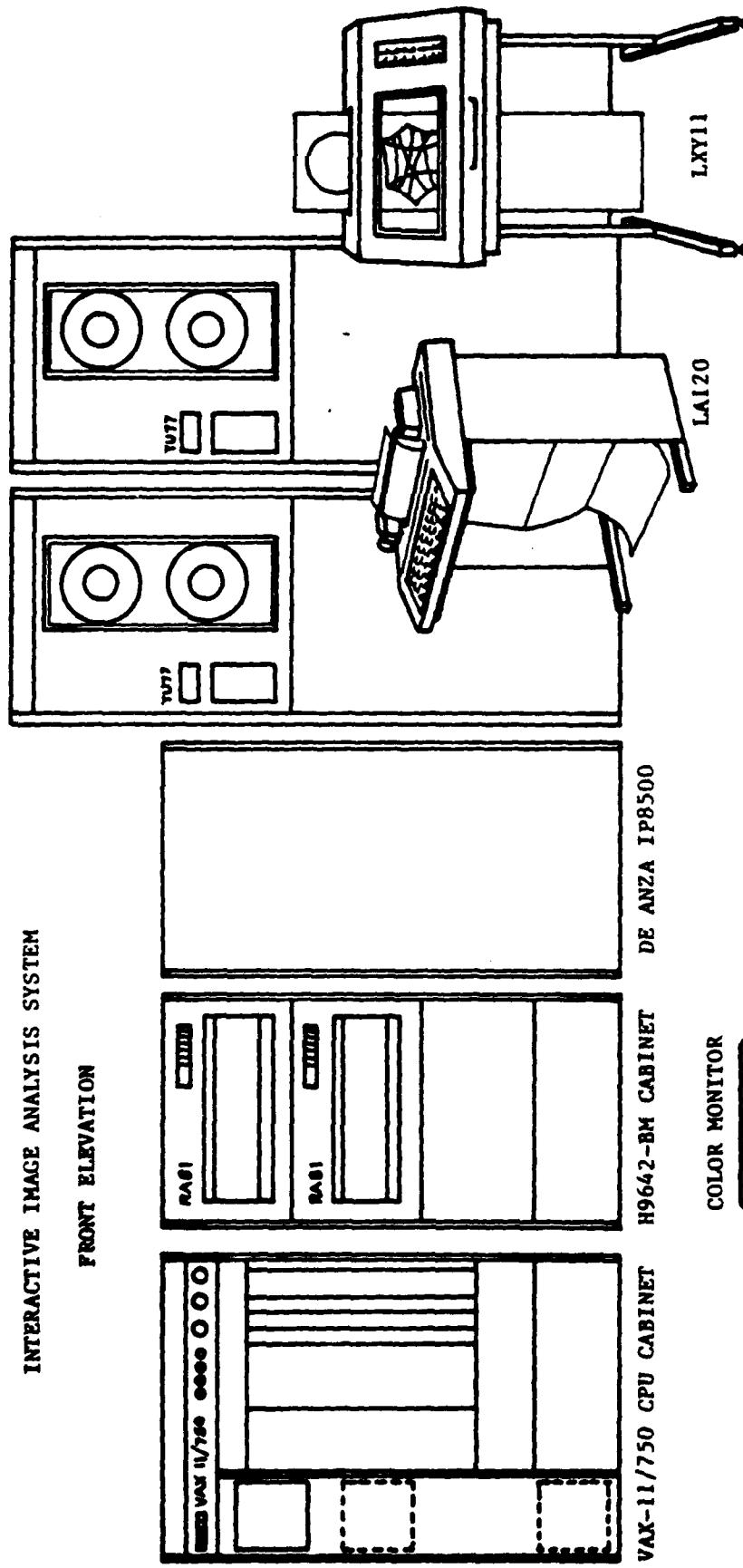


Figure 3-4

HARDWARE  
RECOMMENDATIONS

Table 3.4  
Hardware List

Quan.	Model	Description	Vendor
1	SV-BXEBA-CA	VAX 11/750 with 3 Mbytes main memory,	DEC
1	LA-120	Console Terminal	DEC
2	RA 81	456 MByte Fixed Disk Drive	DEC
2	TU 77	Magnetic Tape Drive 800/1600 bpi, 125 ips	DEC
1	DZ11A	Asynchronous Communication Controller (8 serial devices)	DEC
1	LXY11-VA	300 Line per minute printer/plotter	DEC
1	VT-125-AB	Graphic terminal	DEC
1	IP8500	Image Analysis station 512 x 512 resolution, five eight bit refresh memories, digital video processor, cursor generator, alphanumeric generator, Unibus interface, 19 inch color monitor, VAX-VMS device driver, Library of image processing software, manuals, installation, hardware histogrammer, trackball, and joystick.	DeAnza

## CHAPTER 4

### SOFTWARE

The software for the IIAS consists of three major components: system software, image analysis utility software, and terrain data extraction application software.

#### 4.1 SYSTEM SOFTWARE

The majority of the system software will be purchased from hardware vendors. This includes:

1. VAX/VMS operating system (DEC)
2. Fortran (DEC)
3. Software development utilities, including a text editor, debugger, Macro assembler, etc. (DEC)
4. IP8500 device driver (DeAnza)
5. Fortran callable image analysis routines (DeAnza)

## SOFTWARE SYSTEM SOFTWARE

A set of utility software will be written for the VAX-DeAnza system, including disk and tape input/output routines and other commonly used functions. Interfaces to these routines will be straight forward and well documented to facilitate use in future ETL projects.

### 4.2 IMAGE ANALYSIS UTILITIES

A library of generic image analysis routines will be used for terrain data extraction. This library will also provide a base for future image processing software.

The image analysis library will consist of many basic image analysis routines developed in the General Electric DIAL facility, augmented by DeAnza's image processing library for the VAX. The library will contain routines to implement the following functions:

#### 4.2.1 Contrast Stretch

1. Real time linear stretch.
2. Piecewise linear stretch.
3. Histogram equalization.

#### 4.2.2 Convolution (7 X 7)

1. Edge Enhancement.
2. Edge Extraction.

SOFTWARE  
IMAGE ANALYSIS UTILITIES

3. Tree Crown Template.
4. Gradient.
5. Laplacian.
6. User defined kernel.

4.2.3 Golay Processing (single Theme Spatial Operations.)

1. Shrink.
2. Grow.
3. Noise clean-up.
4. Blob counting
5. Outline.
6. Skeletonize.

4.2.4 Theme Filtering (multiple Theme Spatial Operations.)

1. Smoothing.
2. Noise clean-up.
3. Resolve spatial errors.

4.2.5 Statistics Generation.

1. Histograms.
2. Two dimensional histograms.
3. Covariance matrix.

SOFTWARE  
IMAGE ANALYSIS UTILITIES

4.2.6 Mensuration

1. Theme area.
2. Cursor area.
3. Control point elevation.

4.2.7 Disk To Interactive Terminal Transfer.

1. By segment corner specification.
2. Overview of disk image.
3. By interactive cursor size and location on overview.
4. Window insertion.

4.2.8 Scale And Resolution Changing.

1. By nearest neighbor mapping.
2. By area averaging.

4.2.9 Texture Extraction.

4.2.10 Box Filtering.

1. Local averaging.
2. High pass.
3. Adaptive.

SOFTWARE  
IMAGE ANALYSIS UTILITIES

4.2.11 Classification

1. Parallelepiped.
2. Level slicing.
3. Two dimensional histogram partitioning.

4.2.12 Real Time Image Combinations.

1. Add, difference.
2. Fade between.
3. Multichannel linear combinations ( $A*(\text{channel 1}) + B*(\text{channel 2})$ )

4.2.13 Cursor Manipulations.

1. Window or crosshair mode selection.
2. Point location.
3. Window size and location.
4. Polygon drawing.

4.2.14 Theme Synthesis

1. Add, subtract, or, and , exclusive or.
2. Training sample gate.
3. Alarm gate.

SOFTWARE  
IMAGE ANALYSIS UTILITIES

4.2.15 Parameter Setup.

1. Number of channels to be analyzed.
2. Gray levels per channel.

4.2.16 Utility Functions

1. Line patch.
2. Densitometer
3. Numeric video dump.
4. Video/theme exchange.
5. Video/theme copy.
6. Test patterns.

4.2.17 Magnetic Tape Save/restore

1. Interactive terminal.
2. Disk files.

4.2.18 Display Control.

1. Channel color assignment.
2. Theme color assignment.
3. Flicker.

SOFTWARE  
IMAGE ANALYSIS UTILITIES

4.2.19 Terrain Data Extraction

Application software implementing the terrain data extraction function will be provided. This software duplicates the functions developed by the General Electric Company under contract DAAK 70-79-C-0153, and implements the functions described in section 2.1. Since the GE DIAL system is based on an Image 100 display device (which is no longer available) and a PDP 11/35, the terrain data extraction software is not directly transferrable to the VAX-DeAnza (or any other system considered). However, similarities between the VAX and PDP 11/35 will minimize transfer problems.

The application software implements the following functions:

1. Read digitized aerial photography from tape and store the data in a standard format on disk.
2. Interactive interface for selection of data on disk.
3. Interactive menu driven interface to each of the image analysis library functions.
4. Control point selection.
5. Mosaicking.
6. Scaling.

SOFTWARE  
IMAGE ANALYSIS UTILITIES

7. Radiometric equalization.
8. Control of the classification process.
9. Polygon generation.

## CHAPTER 5

### IMPLEMENTATION

This chapter presents a work breakdown structure (WBS) for the implementation of the IIAS. The WBS includes:

1. All hardware listed in table 3-2.
2. All software described in section 4.
3. System integration.
4. Documentation, specifically: operational guides, software documentation for all newly developed software, functional descriptions of all software, and a system description document.
5. All consumables and maintenance agreements for the development period.

The cost presented specifically does not include:

## IMPLEMENTATION

1. Training of ETL personnel.
2. Shipment of IIAS to ETL.
3. Installation of IIAS at ETL.
4. Algorithm development (beyond that performed under contract DAAK 70-79-C-0153)

In order to calculate cost data, the following assumptions were made:

1. All GE DIAL software required for the terrain data extraction process is available.
2. GE DIAL applications software will be used to the maximum extent possible. Modifications will be made only as required for the GE DIAL PDP 11/35 to VAX 11/750 transfer.
3. Functional descriptions of transferred GE DIAL software and purchased software will be provided. All other documentation will be as delivered under DAAK 70-79-C-0153 or by the hardware vendors.
4. Software documentation for newly developed software will be provided.
5. The system will be developed and integrated at the contractor's facility.

6. Rigorous "Mil-spec" documentation and software development standards are not required.
7. ETL will provide interface control documents, test imagery, and integration testing time on TASS.

The following paragraphs describe the work breakdown structure to the second level.

#### 5.1 PROJECT MANAGEMENT

##### 5.1.1 Project Office

This structure includes a part time project manager and secretarial support.

##### 5.1.2 Finance And Contracts

This structure includes all financial and contractual support required to execute the contract.

##### 5.1.3 Travel And Living

Includes travel expenses for 12 two person trips (one each month) to ETL to support the contract.

## IMPLEMENTATION SYSTEM ENGINEERING

### 5.2 SYSTEM ENGINEERING

#### 5.2.1 Technical Lead

This structure includes the full time activities of the IIAS technical lead. Responsibilities include system definition, development support, customer interface, and turnover test direction.

### 5.3 HARDWARE

Included are all equipment, materials, and labor hours required to configure the IIAS hardware at Lanham, MD.

#### 5.3.1 Equipment

This structure includes all equipment and purchasing labor hours.

#### 5.3.2 Hardware QA

This includes receiving equipment, witnessing and validation of all vendor hardware acceptance tests, and preparation of the facilities at Lanham.

### 5.4 SOFTWARE ENGINEERING

IMPLEMENTATION  
SOFTWARE ENGINEERING

5.4.1 Utility Software

This activity includes design and implementation of all utility software for the VAX-DeAnza image analysis system. This includes translation of existing DIAL utilities to VAX-DeAnza equivalent routines, generation of software to simulate Image 100 features not available on the DeAnza, and generation of tape to disk to refresh storage utility software.

5.4.2 DIAL Software Transfer

This activity includes all functions necessary to allow the existing DIAL applications software function on the VAX-DeAnza system. Primary activities are expected to include translation of assembly language DIAL software and changes for VAX-PDP 11/35 differences (such as Send-Receive, Encode-Decode, and integer lengths). Also included is generation of all new software, including control software and additional image analysis software.

5.4.3 Integration And Testing

This activity includes integration of software and formal turnover testing. Included are test plan generation, formal testing, and generation of operations manuals.

IMPLEMENTATION  
SOFTWARE ENGINEERING

5.4.4 Software Support

This includes management, secretarial, word processing, operations, and system software support for the software effort.

5.4.5 Software Quality Assurance And Configuration Management

Included are reviews of new software and documentation against standards, witnessing of integration tests, and baselining of all software.

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